A Data-driven Approach for Estimating Irrigation Groundwater Use for the Western United States

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The Western United States (Western US) consists of some of the most significant and heavily pumped aquifers in the country. A significant portion of the pumped groundwater is supplied to irrigate the farmlands of this region. To ensure sustainable agriculture and avert detrimental effects like land subsidence and aquifer depletion, monitoring and quantifying groundwater use at a high spatiotemporal scale has become essential for the Western US. The current monitoring capacity lacks spatial and temporal resolution and limits the ability to assess irrigation groundwater use at the regional level. We plan to leverage existing satellite products, in conjunction with in-situ datasets and data-driven techniques, to bridge this gap. One key concept related to satellite-based groundwater use estimation is "effective precipitation", which is very challenging to quantify and validate with no currently available dataset. Effective precipitation can be defined as the fraction of precipitation that supplements irrigation. Knowledge of effective precipitation is crucial to understand the dynamics between precipitation, evapotranspiration, and groundwater pumping, as effective precipitation drives the amount of irrigation required. In this study, we employed a machine learning approach to measure effective precipitation utilizing high-resolution OpenET datasets. The machine learning model uses gridded precipitation, weather, and land use products as input variables and generates effective precipitation estimates at a high spatial resolution of 2 km. In the next step, these estimates are applied in a water balance equation to measure consumptive groundwater use for the Western US. As consumptive groundwater use and groundwater pumping are separated only by the factor of irrigation efficiency, the produced consumptive groundwater use dataset serves as a reliable proxy for groundwater pumping. Moreover, the consumptive groundwater use estimates can validate the effective precipitation estimates. Comparison of the consumptive groundwater use estimates with groundwater pumping data in basins over Kansas and Arizona showed good agreement, validating our effective precipitation approach. This is a step forward toward producing historic groundwater pumping estimates for the entire Western US. Our high-frequency effective precipitation and consumptive groundwater use datasets will provide valuable information in regional-scale groundwater pumping estimation, water budget estimation, and sustainable groundwater planning.